No. LV.

A Letter from Captain William Jones, of Philadelphia, to the President of the Society, communicating sundry queries proposed by him to William Jones Esquire, Civil Engineer of Calcutta, relative to the principles and practice of building in India, with his answers to the same.

Read June 17th, 1808.

Philadelphia, June 17th, 1808.

DEAR SIR,

WHEN in Calcutta, I had the pleasure to become acquainted with Mr. William Jones, whose profession is that of a civil engineer, and who at the time was employed in constructing a dry dock of great capacity, calculated to receive a man of war when the water of the Ganges was at the lowest.

He is distinguished as a man of genius, of much philosophical knowledge, and of great practical experience in all the branches connected with his profession. He regretted that the urgency of his pursuits precluded him from rendering his remarks more perfect and comprehensive than the papers herewith enclosed; and proffered a correspondence with me on any subject which I might deem interesting.

Should the Society desire information, from that quarter, on any subject of philosophy, natural history, or the mechanic arts, I will cheerfully avail myself of his kind offer.

You will perceive that Mr. Jones has said nothing relative to public roads—he did not consider the manner of constructing them in that country as applicable to this.

I know not whether there is any thing in the communication I have to make, that will be new or interesting to the Society; if not, I trust the desire to be useful will constitute my claim to indulgence.

I am, very respectfully, yours,

WILLIAM JONES.

Copy of a letter from William Jones of Philadelphia, to William Jones Esquire, Civil Engineer, of Calcutta.

Calcutta, December 26th, 1807.

MY DEAR SIR,

Your obliging assent to my solicitation for a memorandum of the manner of constructing a *terrace roof* in this country, and a desire to avail myself of such information relative to the arts of other countries, as may be useful in my own, prompts me to ask of you a brief communication of the principles and practice of building in India, with such observations as your experience may suggest.

I look for indulgence, in the liberality of sentiment and love of science and the arts, which general suffrage has attached to your character. A desire of individual information alone, could not have induced me to trespass on time and attention so assiduously and usefully employed, but my intention is, to present your communication to the American Philosophical Society at Philadelphia, which will unite with its associate in a just sense of the obligation.

A knowledge of the composition of cements, and of the quality and combination of materials employed in architecture in India, the excellence of which has been consummated by the lapse of ages, is an object of great interest in America. The structure of public roads is no less so: I am told there are some very excellent in India; any information on that subject, with a view to economy, durability, and a solidity impervious to intense frost, will be highly acceptable.

I beg leave to present a few queries connected with the object in contemplation.—They are suggested by the local circumstance of climate and architecture in America.

1st. What are the materials, and what is the quality of the cement, used in constructing the walls of buildings in India?

2d. Are the walls below the surface, of the same materials?

3d. What is the thickness of the exterior, as well as of the interior walls, in proportion to the elevation?

4th. What are the component parts of the plaister of the exterior and interior walls?

5th. How, and of what materials, is the roof formed?

6th. What is the thickness of the terrace on the roof, the process of laying it, and the composition of the materials?

7th. What are the proportionate dimensions, and what is the relative strength *to oak timber*, of the beams which sustain the roof?

8th. Is the thickness of the walls deemed necessary to sustain the incumbent weight of the roof *alone*, or is it partly to resist heat—or is the extraordinary thickness in consequence of the fragile quality of the brick?

9th. Do you think a roof so constructed capable of resisting the intensity of the frost in North America?

10th. Is a horizontal roof, so constructed, capable of sustaining any great additional weight, such as the superincumbent weight of snow, which, in America, is frequently three or four feet deep?

11th. How, and of what materials are the floors constructed; and what is the quality and thickness of the cement which forms the floor?

12th. What is the proportionate elevation of the ceilings?

13th. What is the quality, and what are the component parts of the *water cement*, used in India, and of the celebrated cement and plaister used at Madrass?

14th. Is shell or stone lime preferred, and does the lime of India possess any intrinsic superiority over the shell or stone lime of Europe or America?

15th. Does sugar, molasses, or animal or vegetable oils, form a part of any of the cements used in India?

16th. I am told that the iron exclusively used in the fastening of all ships built in India, (even that which secures the sheathing boards) is completely protected from the corrosive effects of the copper, by the coat of Chunam [lime and animal or vegetable oil thoroughly amalgamated] one fourth of an inch thick, which is between the main plank and the *sheathing boards*, and also between the latter and the copper sheathing; and that the iron of coppered ships has been found in perfect preservation after ten years' service. Do these facts come within your knowledge?

17th. Is the quantity of manual labour necessarily implied in any of the foregoing queries, such as to forbid the adoption of the practice in America, (where the command of that force is extremely limited and expensive) or can the difficulty be obviated, in any degree, by the employment of other agents?

I will not reiterate my apologies, but assure you of the sincere pleasure I shall derive from any occasion you may find to command my services.

I am very respectfully
and sincerely yours,
WILLIAM JONES.

To WILLIAM JONES Esq.
Seibpore, near Calcutta.

Answers to 17 *Queries propounded by William Jones of Philadelphia, to William Jones Esq. Civil Engineer, of Calcutta.*

1st. Buildings in Bengal are generally constructed of bricks, formerly nine inches, but now eleven inches in length;—the additional size saves the cement, which is dearer than bricks.

The cement is made of two parts brick dust, one part sand, and one part stone lime—brick dust, alone, would be preferred, but sand being cheaper is used. The mortar is mixed in the common way, but the bricks are laid like what the masons call *grouted work*, which is done by laying the outward courses first, and then filling up the middle space with bricks, small and large, swimming in water and cement, so that no crevice remains open.

Arches, columns, &c. are made with cement, two parts brick dust and one part lime, all sifted fine. The bricks are dipped in water separately as they are laid, for which purpose a vessel of water is placed between every two workmen.

2d. The walls below the surface are of the same materials as those above, but some people, regardless of the expense, lay one course, just above the floor, in lime and oil, the whole thickness of the wall, and afterwards continue the building in the common way—this *forever prevents* damp from rising.

3d. The interior as well as the exterior walls are all of the same thickness, because our houses sink altogether about six inches, or more, and the partition walls in a terrace roof have to sustain their share of the weight with the outer ones. We build the lower story two feet six inches, the second two feet, and the third one foot six inches thick; but you may build your first story two feet, the second one foot nine inches, and the third one foot six inches thick; as you may use *bond timber*, from which we are precluded by the ravages of the white ant.

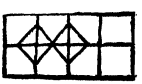
4th. The exterior plaistering is made of three parts washed sand, and one of stone lime, laid on in the common way, but rubbed with a small bit of wood until it sets—the joints are first well opened with a bit of crooked iron.

The inside work is done the same way, and with the same materials, and when dry, coated with shell lime. The shells are cleaned before they are burnt, and when taken from the kiln, the whole are cleaned and picked from the dust (which is a dirty lamina, that falls off in the calcination) and put into a trough, where they are triturated and slacked with a little water, and when mixed to a thick consistence, deposited in earthen jars, or other vessels, for use.

When to be used, a bed of sand or clay is made on the ground, hollow in the middle, and covered with coarse cloth. The lime is strained through a fine cloth that is placed about two or three feet above the bed.—It is mixed with clean water, in order to pass the fine parts in solution through the strainer—the coarse is rejected. It must lie three or four days on this bed to cool, before it is used, or the work will crack. It is mixed with a sufficient proportion of milk that has undergone a fermentation by *leven*, so that the whole is in a curd, without any whey. Of this material the quantity is ascertained by mixing a little and plaistering on a tile.—In fine work, the white of eggs is used in large quantities, and in some cases a small quantity of calcined agate, pulverised—but this kind of work will never answer in your country, as the labour is very expensive. It is the work of many days after the plaister is on, to rub and wipe it; otherwise it would crack on the surface, and so long as a crack appears, the rubbing must be continued.

The wall will sweat for several days; but the water must be constantly wiped off with fine, clean cloths, or the whole work will turn red. A wall finished in this way may be washed with soap and water; but when the plaister breaks, it is not easy to mend it without the patch being visible. Stucco walls will answer much better in America, and would be used here if we had the plaister.

5th. The roof is formed by simply laying beams of wood from wall to wall, in the shortest direction, three feet from centre to centre. Upon these beams are laid transverse pieces of wood, three by two inches thick, to support the tiles or bricks. We use twelve inch tiles, and lay the transverse pieces of wood so that the tiles join in the middle. Our tiles are one and a half inches thick, and are laid in two courses, well bedded. The upper course must break or cover the joints of the lower, thus,



The roof is then ready to receive the terrace. The transverse pieces of wood are not nailed, but the spaces between are filled up with mortar and bits of brick tile &c. so that they cannot shift.

6th. The terrace is six inches thick, when finished, at the middle, and about four inches at the outer walls, independent of the tiles and wood. Wherever it is determined to deliver the water, there must be gentle descents towards those places coming to a narrow focus at the spout. The composition is broken brick, the pieces about four cubic inches, or just as it happens to break; they must not be too small, or the terrace will be liable to crack.

Take the broken bits, dust and all, as they lie for use—measure the whole and count the number of measures of any kind—spread it one foot or thicker, on the ground—level and water it well, turning it over at the same time. This deprives the brick of its over absorbent power.

For every three measures of broken brick, you must use one of the same measure of good stone lime, giving only one third at a time, watering and turning it every day for four days;

the three first days you divide the lime, giving a part each day with a little shell lime mixed with water.—It is now ready to be carried up to the roof, where it is to be expeditiously spread in the shape you want it, and the beating business commences. On a small roof you must employ at least fifty people, women and children will answer, with a few bricklayers, constantly, to see that the materials are laying right. They must all sit down on any thing you find convenient, and continue beating sharply and hard for three days, with a piece of wood about three by two inches thick, and sixteen inches long, handle and all, shaped thus,

The substance must be constantly wetted, taking care that the lime be not washed out. At the end of three days, the hard beating must be abated (as the work is beginning to set) and the watering diminished.

For two days more, the beating must be only a little constant patting, very light, but the fourth day, all the rough face must be filled up with bits of brick, not more than half a cubic inch in size, with the fine dust sifted out; this last must be well mixed with lime, one third its quantity, and rubbed with plenty of water all over the terrace, and a little shell lime added; while this is thin and soft, the beating must be constant, but very light, merely paddling in it with the beaters; as it becomes dry, the beating may be increased to a tolerable sharp blow, constantly filling up every inequality. The sixth day, the surface must be covered with fine brick dust and lime, as before, and the paddling or gentle beating recommenced, adding a little of the juice of the sugar cane, or you may use molasses. At nine days end it ought to be finished, but you had better, in your climate, continue it thirteen days, as patience in this case will afterwards reward you. If it should rain often it will make the business more tedious, and if the rain be heavy you must cover the work with something, or the lime will be washed out. When the beaters rebound from the terrace as if they struck stone, and the sound is clear, you may conclude it is done.

Keep a few people for five or six days, rubbing the surface with water, lime and molasses mixed, so long as a crack appears, and afterwards rub the whole over with any common oil. It is difficult to describe this process, but a little experience will point out what is necessary.

7th. The annexed table of the gravity and strength of wood will inform you.

Result of experiments made on the weight and strength of timber used in Bengal.

The pieces on which the experiments were made, were each square prisms, twenty-four inches long, and one inch on the side; the distance between the props of support was twenty-two inches, and the weight was suspended from the center of the piece.

	Names of the wood	Weight of each piece. oz.	Weight suspended when it broke. lb	oz.
Native.	Teak.	11	449	13
	Tissoo.	12½	459	5
	Saul.	13	535	12½
	Assum, like Saul.	13½	539	9
	Soondry.	15¼	593	9
	Napaul Fir.	9⅝	389	0
European.	Baltic red Fir*	10	346	9
	Ditto white Fir†	7	214	13

* Very dense and full of rosin. † In general use.

N. B. A quantity of pure water, of the same bulk with one of the above pieces of wood would weigh 13⅞ ounces. Hence they would all float in water except the *Soondry*.

You must not use knotty or curled wood for your beams, and all beams must be rounded or cambered upwards, in the proportion of two inches to twenty feet, as the terrace will bring them down a little.

In a twenty-two feet space, Saul beams, ten by seven or eight inches, are quite sufficient, placed at three feet from centre to centre.

We remove beams when rotten without injury to the terrace. The wall-hold is generally six inches less than the thickness of the wall.

8th. In the thickness of the wall, resistance to heat is not considered. Strength is alone considered. We cannot, as I remarked before, use any bond timber or ties of any kind on account of the destructive vermin.

The bricks contain much sand, salt, alkali, and other fusible matter, and will vitrify before they are well burnt.

You have seen many walls thicker than the dimensions I have given, but those are built with brick and mud, and having no cement require to be thicker.

9th. If you begin your work early, so that it will be completely dry, it will resist any frost, but if any moisture remain within, the frost will rend the work.

10th. Add a little strength to your timber, make the parapet low, take care before a thaw to throw off the snow, keep the spouts open, and it will sustain double (or more) the weight you mention.

11th. The floors the same as the roof, but a little lighter, and not so much cove.

12th. Stick to the common and ancient rules of architecture in all cases; but doors and windows, make them much larger.

13th. Water cement is made of brick dust, lime, and the juice of the sugar cane. The Madrass plaister is as I before described ours.

14th. Stone lime is cheap and used for common purposes, shell lime is dear and only used with fine work; I believe it is no better than your own.

15th. No further than I have before described.

16th. These facts do come within my knowledge, and are true. It forms a crust impervious to water, and must protect any thing it covers. When dry, it will keep a ship afloat after her caulking is perished and loose.

Much oil is saved in making this article by bestowing labour on the beating and mixing of it.

17th. Where manual labour is an objection I have stated it.